U.PORTO

MESTRADO INTEGRADO EM
PSICOLOGIA CLÍNICA E DA SAÚDE

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M

2019

U.PORTO
FACULDADE DE PSICOLOGIA
E DE CIÊNCIAS DA EDUCAÇÃO
UNIVERSIDADE DO PORTO

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outubro 2019

Dissertação apresentada no Mestrado Integrado em Psicologia, área de Psicologia Clínica e da Saúde, Faculdade de Psicologia e de Ciências da Educação da Universidade do Porto, orientada pela Professora Doutora ***São Luís Castro e*** Doutora ***Susana Silva*** (FPCEUP).

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Agradecimentos

À professora São Luis Castro e à professora Susana Silva por toda a orientação, disponibilidade e apoio ao longo deste processo.

À Exm.ª Diretora Anisabel Carneiro Moniz Robinson e a todos os profissionais do Estabelecimento Bela Vista, nomeadamente à Drª Nair Caldeira, responsável do Ginásio Multissensorial, pela permissão e recetividade ao propor que parte da minha amostra fosse recolhida com a colaboração dos seus utentes.

Ao grupo de investigação de Neurocognição e Linguagem/Laboratório de Fala FPCEUP, nomeadamente à Drª Andreia Nunes, pela cooperação e por me ter cedido a chave do laboratório para lá recolher, também, a minha amostra.

Aos estagiários, Catarina Botelho, Daniel Sobrinho e Hélia Rocha pela ajuda e contributo neste projeto.

Aos meus amigos e colegas de curso, especialmente à Cátia, à Daniela, ao João, à Adriana e à Bruna por terem passado comigo por todas as fases destes cinco anos e por, nesta última e mais complicada, terem continuado.

Ao Bernardo, por cada palavra de incentivo, mas, acima de tudo, pela paciência e tolerância.

À Cláudia, por todo o apoio enquanto estávamos geograficamente distantes e agora, mais do que nunca, enquanto colegas de casa, enquanto família. Pela nossa amizade ser das únicas certezas que tenho na vida.

À minha família, especialmente aos meus pais e ao meu irmão, por nunca terem posto em causa os meus objetivos e por terem facilitado todo o processo sabendo que teria e terei sempre o seu apoio. É por mim, mas é graças a vocês que consegui chegar aqui.

Resumo

A música de fundo pode facilitar a codificação de materiais verbais em comparação a contextos auditivos não musicais, mas as causas desse fenómeno ainda permanecem pouco exploradas. Testámos se a vantagem da música depende do seu impacto emocional ou da sua capacidade de aumentar a atenção numa tarefa de codificação. Por isso, analisámos se a preferência (envolvimento emocional) ou a familiaridade (melhoria da atenção) com a música de fundo modula a vantagem da música em relação ao silêncio e aos sons ambientais no desempenho da memória episódica. Pediu-se a jovens adultos (Experiência 1) e idosos saudáveis (Experiência 2) que codificassem uma lista de palavras (palavras *old*) enquanto ouviam silêncio, sons ambientais e três excertos de música instrumental. Os excertos foram classificados de acordo com a preferência e familiaridade dos participantes. Comparámos a capacidade dos participantes em discriminar palavras *old* e *new* (memória de item) em função do contexto auditivo, em função da preferência (silêncio, sons ambientais, música preferida, música não preferida) e familiaridade (silêncio, sons ambientais, música familiar e música não familiar), bem como as suas capacidades para recuperar o contexto auditivo (memória de fonte). Em ambas as experiências, verificámos uma vantagem da música preferida em relação aos outros contextos na memória de item e também na memória de fonte. Não houve vantagem da música familiar nos jovens adultos (Experiência 1), mas houve um efeito marginal na memória de item nos mais velhos (Experiência 2). Os nossos resultados sugerem que o envolvimento emocional pode ser um mecanismo importante para compreender os efeitos facilitadores da música de fundo na codificação e apontam para aplicações importantes relacionadas com a melhoria do desempenho cognitivo ao longo da vida.

Palavras-chave: música, preferência, familiaridade, envolvimento emocional, atenção

Abstract

Background music can facilitate the encoding of printed verbal materials compared to non-musical auditory contexts, but the reasons for this remain underexplored. We tested whether the advantage of music relies on its emotional impact or on its ability to enhance attention to the encoding task. To that end, we analysed whether the preference for (proxy for emotional engagement) or the familiarity with background music (proxy for attention enhancement) modulate the advantage of music over silence and environmental sounds in episodic memory performance. Young adults (Experiment 1) and healthy older adults (Experiment 2) – were asked to encode (old) words while listening to silence, environmental sounds and three instrumental music excerpts. The excerpts were classified according to participants' preference and familiarity. We compared participants' ability to discriminate between old and new words (item memory) as a function of preference-related auditory context (silence, environmental sounds, preferred music, non-preferred music) and familiarity-related auditory context (silence, environmental sounds, familiar music and non-familiar music), as well as their ability to recall the auditory context (source memory). In both experiments, we saw an advantage of preferred music in item memory and also in source memory. Familiar music had no advantage in young adults (Experiment 1), but there was a marginal effect on item memory in the older ones (Experiment 2). Our findings suggest that emotional engagement may be a key mechanism subtending the facilitating effects of music backgrounds on encoding, and they point to important applications concerning cognitive enhancement across the life span.

Keywords: music, preference, familiarity, emotional engagement, attention

Introduction

Music is incorporated in many aspects of everyone's life. The act of listening to music is often motivated by the search for an aesthetic experience (Phelps III, 2014), but there is also an increasing awareness that other types of effects may arise — such as cognitive enhancement (Greenberg et al., 2015; Kang & Williamson, 2014; Li et al., 2015; Ludke et al., 2014; Mammarella et al., 2007; Moussard, Bigand, Belleville, & Peretz, 2012; Racette & Peretz, 2007; Simmons-Stern et al., 2010; Wallace, 1994) and, more specifically, memory improvement (Chew et al., 2016; Ferreri et al., 2013; Giannouli et al., 2018; Peretz et al., 1998; Simmons-Stern et al., 2010; Smith, 1985; Thaut, 2010). An important application when it comes to the impact of music on memory performance concerns the effects of background music on the encoding of new materials – for example, as when one studies while listening to music.

While there is evidence suggesting that background music can negatively affect memory, since it distracts from the information to be remembered and impairs memory performance (Moussard et al., 2012; Racette and Peretz, 2007), a considerable number of studies suggested that background music can have a positive effect on encoding tasks , in healthy as well as clinical populations (Balch and Lewis, 1996; Balch et al., 1992; Brotons and Koger, 2000; Chan et al., 1998; Ferreri et al., 2013; Ferreri et al., 2015; Racette et al., 2006; Särkämö et al., 2008; Simmons-Stern et al., 2010; Thaut et al., 2005; Thompson et al., 2005; Wallace, 1994). In Ferreri et al.' s (2015) study, it was shown that background music facilitates the encoding of printed verbal materials not only when music is compared to a silent context, but also when compared to non-musical auditory contexts such as environmental sounds. Therefore, the advantages of music seem to be specific, and not auditory-general.

Despite considerable evidence that background music enhances the encoding of new materials, the subtending mechanisms are still underdetermined. Why music? One possibility is that the strong emotional impact of music (Blood and Zatorre, 2001; Salimpoor et al., 2013) works as an additional cue that strengthens the encoding of an event. Given that the emotional function of music is critical in inducing preference (liking) for a given piece of music (Schäfer & Sedlmeier, 2010), one could hypothesize that increased preference enhances the facilitating effect of music on encoding compared to non-emotional auditory contexts (silence, environmental sounds). Another possibility relates to the fact that familiar music (vs. silence and non-familiar music) increases the levels of attention, with an impact on vigilance tasks performed concurrently (Fontaine & Schwalm, 1979). There is also evidence that familiar sounds are a less distractive background during cognitive tasks than non-familiar sounds (habituation hypothesis, Wolf & Weiner, 1972). From both these viewpoints, increased familiarity of background music should also enhance the encoding of new materials compared to non-familiar music (habituation hypothesis) and, possibly, compared to silence and environmental sounds (impact on attention).

In the present study, we examined how preference and familiarity in music modulate the advantage of instrumental music (see Mcdonald, 2013, for a discussion on vocal vs. instrumental music) over silence and environmental sound backgrounds when printed verbal materials are being encoded. Following Ferreri's et al. (2015) paradigm, we considered encoding from the perspective of episodic memory and examined the effects of the auditory context on its two components: item memory and source memory (Glisky, Polster, & Routhieaux, 1995). While item memory stands for the content of the encoding context, source memory stands for the background information in which the content is being encoding (Easterbrook, 1959). The two components may dissociate (Glisky et al., 1995): for instance, when a person describes an emotive situation they pay more attention to what they consider a central information (e.g. having a car accident, as item memory) and neglect the background information (e.g. what music was playing in the radio when the accident occurred, as source memory). In Ferreri et al.'s study (2015), music had an advantage over environmental sounds and silence in both item (recognizing a printed word as old or new) and source memory (indicating the auditory context where the word appeared), suggesting that music is beneficial for episodic memory in its two dimensions.

In addition, given that cognitive and, more specifically, memory improvement is a major concern when dealing with the consequences of aging – whether it is healthy (Souchay, Isingrini & Espagnet, 2000) or pathological (Janowsky, Shimamura & Squire, 1989) – we ran the paradigm with two different samples: younger adults (Experiment 1) and healthy old adults (Experiment 2), using a simpler stimulus set in the latter case.

In sum, considering music as a potential enabler of encoding, we predicted that an auditory context of preferred music could facilitate the encoding of printed verbal items (item memory) and of the auditory context itself (source memory) relative to silence, environmental sounds and non-preferred music. We also predicted that familiarity could have a similar effect. Our findings will contribute to clarify the mechanisms subtending the enhancing effects of music on encoding, and they may provide direction for practical implications, namely on the optimization of study/work conditions in younger adults, and, most importantly, as an interesting tool to promote healthy aging.

Experiment 1

1. Method

1.1. Participants

Fifty-one university students (45 women, mean age $\pm$ *SD* = 19.9 $\pm$ 1.9 years) participated in the experiment. All participants had normal hearing and normal or corrected-to-normal vision, and did not report any psychiatric, neurological and cognitive problems. All participants signed informed consent according to the Declaration of Helsinki.

1.2. Materials

Verbal stimuli consisted of 45 + 45 = 90 words selected from the PORLEX database (Gomes & Castro, 2003, see Appendix 1). One set of 45 words was presented at the coding phase (old words, to be remembered), and both sets (old and new, 45 old + 45 new) were presented at the test phase. Old and new words were matched for length, frequency and lexical status (verb, noun or adjective).

Audio stimuli (auditory contexts during coding) consisted of 20-second audio files containing silence, environmental sounds (water running and birds, simultaneously) and three instrumental (non-vocal) musical excerpts (five audio files in total). The audio file containing environmental sounds was extracted from a recording that was available online (https://www.youtube.com/watch?v=8myYyMg1fFE).

The three musical excerpts were selected from an initial pool of 12 instrumental songs, following an online pre-test with 20 university students (see Appendix 2). The pre-test was run with the goal of selecting maximally-contrasting music stimuli in terms of preference and familiarity. The initial set contained songs from four different and potentially contrasting music genres (3 examples per genre, 3 x 4 =12): metal, hip hop, electronic and jazz. For each song, pre-test participants were asked to rate the level of familiarity (whether they knew it or not, two levels) and preference (scale with 10 levels, where 1 means “I don't like it” and 10 “I like it a lot”). We analyzed the pre-test data per subject, with the initial aim of determining preference contrasts: we listed the most contrasting song pairs per subject and then counted the frequency of occurrence of such pairs across subjects. Among the candidates for maximally-contrasting songs (song pairs with highest frequency across participants), we chose the three songs that also presented the highest contrasts in terms of familiarity. The final selection included “John and the Creatures - Heres to the Crazy Ones” (metal genre), “Robert Miles – Children” (electronic genre) and “Thelonious Monk - Blue Monk” (jazz genre) (Appendix 2).

All audio files except the silent one were normalized to 70 dB. The start and end points of music excerpts coincided with structural breaks in the song, thus avoiding abrupt transitions.

1.3. Procedure

For the coding phase, the 45 old words were randomly divided into five lists of nine words (5 x 9 = 45), and each of these five-word lists was presented in a different auditory context (silence, environmental sounds, music 1/metal, music 2/electronic, music 3/jazz). We created three versions of the coding phase, each with a different pairing between word lists and auditory context: our goal was to avoid possible pre-existing semantic associations between a specific word and an auditory context (e.g., the word “alumínio” could be associated to the metal genre more easily than to jazz). This also allowed us to dissociate auditory context effects from primacy/recency ones (words at the top/bottom of the list being more memorable). The three versions of the experiment were balanced across subjects.

The 20-second auditory context was presented before and after each word list. Single words were presented on the screen for 5 seconds, always preceded by a 200-ms fixation cross. Thus, participants started each of the five blocks of the experiment by listening to the auditory context for 20-seconds, then they saw the words in silence and, finally, they listened again to the auditory context. Participants were instructed to read the words silently and try to memorize as many as they could, since they would be later tested on this.

At the end of coding phase, participants were given a visual discrimination task (XO letter comparison task, Salthouse, Toth, Hancock, & Woodard, 1997), lasting 5 minutes and working as an interference task. This interference task was critical for testing long-term episodic memory performance and not just working memory (Ferreri et al, 2015). The task consisted of examining a pair of letters (including only X and/or O) and deciding as quickly as possible whether the letters were the same (e.g., XX) or different (e.g., XO). Participants responded by pressing one of two keys in the computer keyboard.

After the interference task, participants were tested for discrimination between old and new words (item memory), as well as for their memory of the auditory context in which the word was presented (source memory). Thus, in this test phase, participants saw each of the 45 + 45 words (old + new), presented in pseudorandomized order, and they were asked two different questions: first, “did you see this word before? YES or NO?”, second, “In which circumstances did you see it?”. Here, there were four response options - SILENCE, ENVIRONMENTAL SOUNDS, MUSIC or DID NOT SEE IT BEFORE.

At the end of the experimental session, participants listened again to the three music excerpts and were asked to rate each of these for familiarity (YES/NO) and preference (1 to 10). These ratings allowed us to determine the contexts of preferred-music, non-preferred-music, familiar-music and non-familiar-music for each participant. The experiment was performed in a quiet room, and stimuli were delivered using Presentation software. We used a 15-inch monitor for visual display and high-quality headphones for audio reproduction.

1.4. Data Analysis

Subject-level d-prime values (Stanislaw & Todorov, 1999) were calculated for each of the five auditory contexts (silence, environmental sounds, metal, electronic, and jazz music). Values were calculated for item memory (discrimination between old and new verbal items) and source memory (discrimination between the target auditory context and the other ones).

Based on each participant's preference and familiarity ratings, new d-prime values were calculated, indicating values for the music context(s) with highest preference (d-prime for preferred music), for the one(s) with lowest preference (d-prime for non-preferred music), for familiar contexts (d-prime for familiar music) and unfamiliar contexts (d-prime for unfamiliar music). In some cases, participants rated a single excerpt as the most liked (e.g., score of 9 against 7 and 5) and a single excerpt as the least liked (the one with a score of 5, in the previous example). In other cases, two of the excerpts had the same score (e.g., 9, 9, 5): in these cases, we averaged the d-prime values of those two excerpts in order to define the d-prime (for preferred music, in this case). We used the same averaging principle when computing the d-prime values for familiar and non-familiar music. Given our dichotomous approach to familiarity (Yes/No responses), there were cases in which all excerpts were rated as familiar or as non-familiar. These cases were left out from the analysis of familiarity effects. When analysing preference effects, we considered first the full sample and then the downsized sample, using only the familiarity-related valid cases.

Effects from the auditory context were tested twice: first, focusing on music preference effects (effects of preference-related auditory context: silence vs. environmental sounds vs. preferred music vs. non-preferred music), and then focusing on music familiarity effects (effects from familiarity-related auditory context: silence vs. environmental sounds vs. familiar music vs. non-familiar music). For each analysis, we considered the effects on both item memory (discrimination between old and new words as a function of auditory context) and source memory (discriminant identification of contexts). All these within-subject comparisons were made with repeated measures ANOVAs, using auditory context as factor and d-prime as dependent-variable. The critical level of significance adopted was .05. Violations of sphericity were compensated with Greenhouse-Geisser corrections. When significant effects from auditory context were observed, we carried out pairwise comparisons across the four levels of the factor, using Bonferroni corrections for multiple comparisons.

2. Results

2.1. Effects of familiarity-related auditory context on item memory and source memory

Twenty-two of our 51 participants rated the three musical excerpts with the same level of familiarity (yes or no), reducing the size of the valid sample to 29 in familiarity-related analyses. With this sample, there were no significant effects of familiarity-related auditory context (silence vs. environmental sounds vs. familiar music vs. non-familiar music), neither on item memory ($F(3,84) = 0.54$, $p = .65$, $\eta^2p = .02$), nor on source memory ($F(3,84) = 0.14$, $p = .93$, $\eta^2p = .01$).

2.2. Effects of preference-related auditory context on item memory and source memory

For the full sample (Figure 1), the effects of preference-related auditory context (silence vs. environmental sounds vs. preferred music vs. non-preferred music) on old-new discrimination (item memory) were significant: $F(3,150) = 14.95$, $p < .001$, $\eta^2p = .23$.

Words initially presented with preferred music were better discriminated than words presented with silence (p = .009, d = 0.57), environmental sounds (p < .001, d = 0.63), or non-preferred music (p < .001, d = 0.57). In contrast, words presented with non-preferred music elicited lower levels of discrimination than the other three conditions (silence: p = .045, d = - 0.47; environmental sounds: p = .024, d = - 0.40; preferred music: p < .001, see above).

When we considered the 29-participant sample (participants entering the analysis of familiarity effects), the results were similar. The effect of auditory context was significant ($F(3,84) = 6.95$, p = .002, η^2p =.19), with preferred music showing advantages over silence (p = .041, d = 0.50), environmental sounds (p = .003, d = 0.57) and non-preferred music (p < .001, d = 0.96). The significant disadvantage of non-preferred music was restricted to comparisons with preferred music (see above; silence: p = .10; environmental sounds: p = .57).

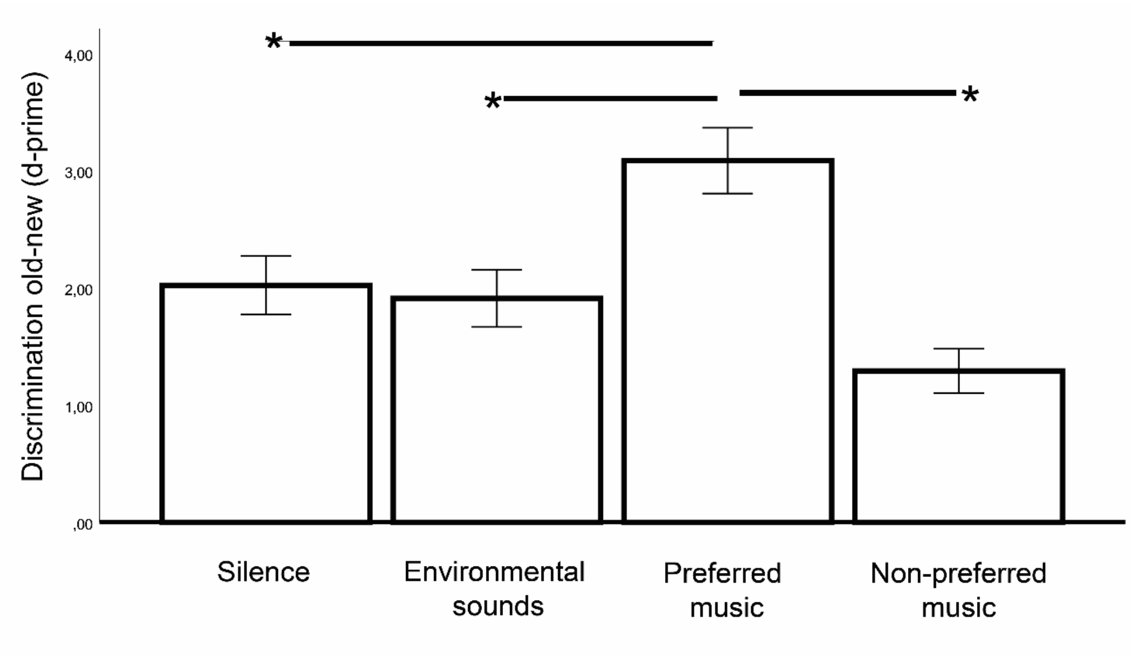

Figure 1. Discrimination old-new (item memory) in the full sample (n = 51) as a function of preference-related auditory context. Preferred music facilitated item encoding compared to the other three auditory contexts.

For the full sample (Figure 2), preference-related auditory context also had a significant effect on source memory: $F(3,150) = 8.61$, p < .001, η^2p =.15. Similar to item memory, the context of preferred music was better identified than all others (vs. silence: p

= .014; d = 0.60; vs. environmental sounds: p = .004; d = 0.54; vs. non-preferred music: p < .001; d = 0.97). Discrimination between non-preferred music, silence and environmental sounds was statistically equivalent (ps > .19).

The analysis made on the 29-participant sample showed similar effects (main effect of auditory context: $F(3,84) = 7.05$, $p < .001$, $\eta^2p = .20$; advantage of preferred music over silence, p = .030, d = 0.53, environmental sounds, p = .023, d = 0.53, and non-preferred music, p < .001, d = 1.23). Non-preferred music was more poorly discriminated than all the other three contexts (silence, p = .029, d = -0.47, environmental sounds, p = .029, d = -0.51, preferred music, p < .001, d = -1.23).

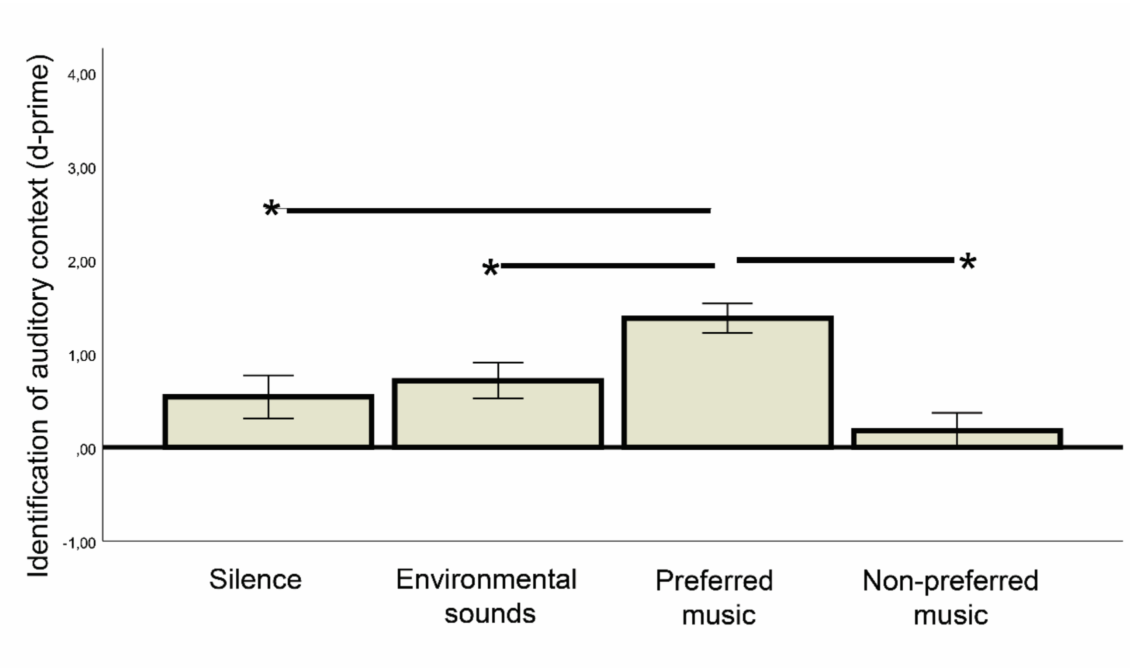

Figure 2. Discriminant identification of preference-related auditory contexts (source memory) in the full sample (n = 51). Preferred music was better discriminated compared to the other three auditory contexts.

3. Discussion

Our results supported the prediction that preferred music facilitates the encoding of verbal material compared to silence, environmental sounds and non-preferred music. The presence of effects of both item and source memory is consistent with the findings from Ferreri et al (2015). Concerning non-preferred music, it seems to be not just unable to improve memory performance: it may *impair* item memory when compared to other auditory contexts. This suggests that the emotional response that may be expected when one listens to preferred music may have a strengthening role in the encoding of verbal material. This also indicates that not all background music facilitates encoding.

In contrast, familiar music did not induce any advantage for item or source memory when compared to the other auditory contexts. This may point to one of two scenarios: either familiar music does not increase attention, or there was an increase in attention that had no effects on encoding.

Experiment 2 aimed at determining whether these effects are maintained in healthy aging.

Experiment 2

This experiment was designed to test the same hypotheses as Experiment 1 (preference and familiarity increase the facilitating effect of music contexts on encoding), but now in the elderly population. Considering the effects of normal aging on cognitive performance, and with the goal of avoiding experimental stress and/or floor effects, we simplified the stimulus set. Also, in order to understand how the effects of musical context may depend on lower cognitive status vs. higher cognitive status we administered to every participant the Mini Mental State Examination (MMSE) adapted to the Portuguese population (Guerreiro, Silva, Botelho, Leitão, Castro-Caldas & Garcia, 1994).

1. Method

1.1. Participants

Twelve healthy older adults (7 women, mean age $\pm$ *SD* = 75.25 $\pm$ 8.3 years; mean schooling $\pm$ *SD* = 4.92 $\pm$ 2.39 years) from a nursing home at Funchal, Madeira island, participated in the experiment. These participants were selected by the local health technician, based on the absence of incapacitating sensory deficits (able to read, non-pathological cognitive function, corrected vision and hearing). Our own examination of cognitive performance using MMSE indicated normal levels of performance in nine participants, and five cases slightly below the cut-off score (17, 19, 21, 22, 22, cut-off of 24 (Morgado, Rocha, Maruta, Guerreiro & Martins, 2009).

Before any contact with the participants, the local ethics committee approved the experiment. All participants signed informed consent according to the Declaration of Helsinki.

1.2. Materials

Verbal stimuli consisted of 10 + 10 words (20) words, taken from the list used in Experiment 1 (see Appendix 3). We selected the words with lower frequency and length, with the aim of facilitating the encoding process. One set of 10 words was presented at the coding phase (old words, to be remembered), and both sets (old and new, 10 old + 10 new) were presented at the test phase.

The silence and environmental sound auditory stimuli were the same as in Experiment 1. We selected the music stimuli based on our previous knowledge about the socio-economic, generational and cultural background of participants: we considered two genres likely to be familiar and/or preferred (fado and traditional local music), contrasting with hip-hop – highly likely to be non-preferred and/or non-familiar. Again, the idea of contrasting musical styles served to prevent the possibility of the same person having the same preference for and/or knowing all the songs from the list. Auditory stimuli were processed in the same way as in Experiment 1.

The Mini Mental State Examination was administered in order to assess cognitive performance of each participant. MMSE is one of the most commonly used screening tools and assesses global cognitive functions in clinical or research contexts, and it is suited to individuals with low educational levels (Guerreiro et al., 1994).

1.3. Procedure

The procedure was similar to Experiment 1, except that there were only 10 old words pseudorandomly divided into five lists of 2 words each. Each list was presented in-between silence, environmental sounds, music 1/hip hop, music 2/fado, music and 3/traditional music.

The MMSE was administered before the experimental task. In order to minimize difficulties associated to the interaction with the computer, the experimenter pressed the keyboard keys after participants provided their responses vocally.

1.4. Data Analysis

The analysis was the same as in Experiment 1. In addition, we computed correlations between cognitive performance (MMSE score) and preference/familiarity effects. The latter were calculated based on subject-level differences between d-prime for preferred/familiar music and d-prime for the other contexts.

2. Results

2.1. Effects of familiarity-related auditory context on item memory and source memory

There was a marginal effect of familiarity-related auditory context on item memory ($F(3,33) = 2.88$, $p = .095$, $\eta^2p = .21$, Figure 3). Multiple comparisons showed an advantage of familiar music over environmental sounds ($p = .023$, $d = 0.89$), whereas non-familiar music did not show any advantage over the other contexts (*p*s > .17).

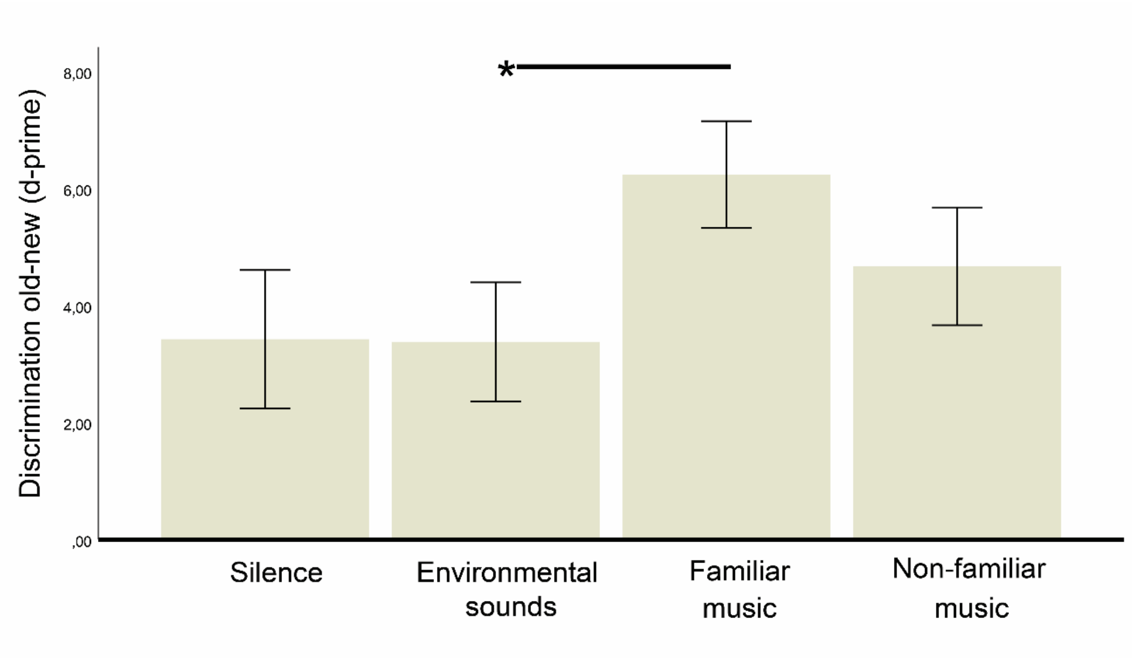

Figure 3. Discrimination old-new (item memory) as a function of familiarity-related auditory context (elderly sample). Familiar music facilitated item encoding compared to environmental sounds.

The effect on source memory was non-significant ($F(3,33) = 0.32$, $p = .81$, $\eta^2p = .03$).

2.2. Effects of preference-related auditory context on item memory and source memory

The effects of preference-related auditory context on old-new discrimination (item memory, see Figure 4) were significant: $F(3,33) = 6.81$, $p < .001$, $\eta^2p = .38$. Old words initially presented with preferred music were significantly better discriminated than those presented with silence ($p = .040$, $d = 0.90$) or non-preferred music ($p < .001$, $d = 2.02$), and marginally better discriminated than those presented with environmental sounds ($p = .072$, $d = 1.03$).

The non-preferred-music context was equivalent to silence and environmental sounds (ps > .54) concerning effects on item memory.

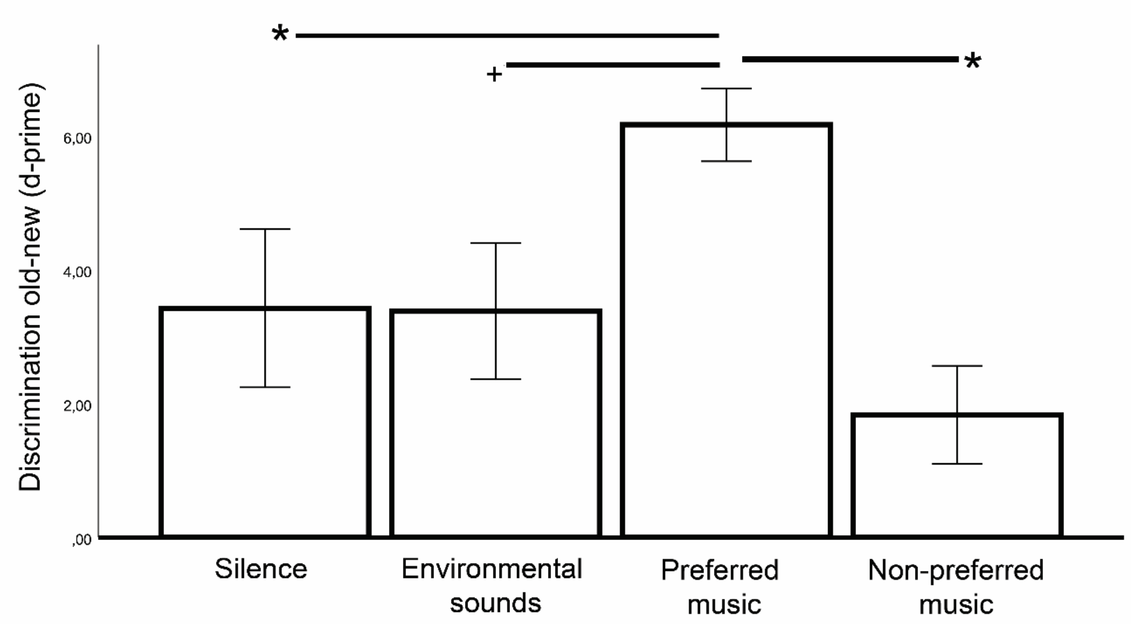

Figure 4. Discrimination old-new (item memory) as a function of preference-related auditory context (elderly sample). Preferred music facilitated item encoding significantly compared to silence and non-preferred music, and marginally compared to environmental sounds.

The effects on source memory were also significant: $F(3,33) = 9.27$, $p < .001$, $\eta^2p = .46$. The context of preferred music was better identified compared to non-preferred music ($p < .001$) and environmental sounds ($p = .040$, $d = 1.30$), but not compared to silence ($p = .33$, $d = 2.14$).

Discriminant identification of the context of non-preferred music was marginally poorer than that of environmental sounds (p = .099, d = -0.86).

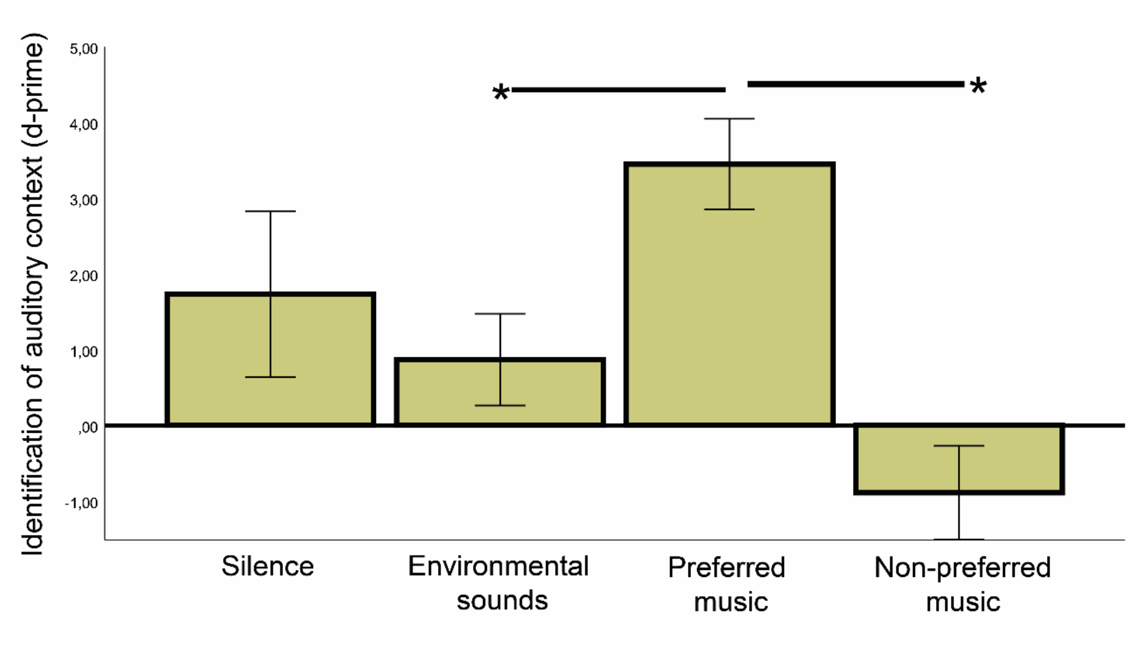

Figure 5. Discriminant identification of preference-related auditory contexts (source memory) in the elderly sample. Preferred music was better discriminated compared to environmental sounds and non-preferred music.

Correlation of preference and familiarity effects with cognitive functioning

The advantage of preferred music over silence (preference effect) in item memory correlated strongly and negatively with cognitive performance (Table 1), suggesting that participants with lower cognitive status are those who benefit more from a background of preferred music during encoding. Even after correcting for multiple correlations (n = 6), the association remains significant (p = .003 * 3 = .018). The remaining familiarity and preference effects did not show significant correlations.

Table 1

Correlation of familiarity and preference effects on encoding (advantage of familiar and preferred music over other auditory contexts) with cognitive performance (MMSE, Mini Mental State Exam)

	Advantage of familiar/preferred music over			
	Silence	Environmental sounds	Non-familiar music	Non-preferred music
Familiarity effect on Item	No advantage of familiar music	r(10) = .441, *p* = .15	No advantage of familiar music	
Familiarity effect on Source	No advantage of familiar music	No advantage of familiar music	No advantage of familiar music	-----
Preference effect on Item	r(10)= -.779, *p* = .003*	r(10) = .286, *p* = .37	-----	r(10) = .009, *p* = .97
Preference effect on Source	No advantage of preferred music	r(10)= .165, *p* = .61	-----	r(10) = .175, *p* = .59

3. Discussion

Similar to younger adults, both item and source memory of elderly participants benefitted from auditory contexts of preferred music. There were nevertheless a few restrictions, in that preferred music was only marginally facilitating compared to environmental sounds when it comes to item memory, and it was not facilitating compared to silence concerning source memory.

In contrast to Experiment 1, familiarity had an effect: we found an improvement of memory performance under familiar background musics compared to environmental sounds, though this was limited to item memory. Therefore, it is possible that familiar music increased the attention of participants, facilitating encoding.

We also found that the advantages of preferred music over silence in item memory correlate negatively with cognitive performance. This indicates that older adults with lower cognitive status may be those who benefit more from replacing a silent background with a background of preferred music when it comes to strengthen verbal encoding. More generally, it may indicate that enrichening encoding with emotional cues is particularly useful under lower cognitive abilities.

General Discussion

This study was designed to better understand why background music can have facilitating effects on the encoding of printed verbal materials. In order to test the hypothesis that music-specific facilitating effects arise from the emotional impact of music or from its status as an attention-enhancer, we examined if preferred (emotionally engaging) or familiar background music (a hypothetical enhancer of task-related attention, Fontaine & Schwalm, 1979) could facilitate episodic memory performance compared to silence, environmental sounds and non-preferred/non-familiar music. Episodic memory was examined for item memory (encoding of printed verbal items) and source memory (their auditory contexts). In order to probe the stability of these hypothetical mechanisms across the life span, we ran two experiments using the same paradigm: one with younger adults, another with healthy older participants.

In line with our hypothesis, preferred music elicited increased memory performance compared to the other auditory contexts in both age groups. This indicates that the emotional impact of music (a generator of preference, according to Schäfer & Sedlmeier, 2010), may indeed strengthen encoding, and that this mechanism may persist throughout the life span. In line with the results from Ferreri et al (2015), both item memory and source memory benefitted from the facilitating effects of music. Nevertheless, there were more generalized effects of preferred music on item memory, suggesting that item and source memory may dissociate in terms of sensitivity to the emotional impact of music.

Concerning the effects of familiarity, these were null in younger adults (Experiment 1). This may indicate either that task-related attention levels were not increased by familiar music, or that increased task-related attention levels did not enhance encoding. Interestingly, the effects of music familiarity on item memory of elderly participants (Experiment 2) approached significance. This apparently increased sensitivity to familiarity may be linked to the age-related attention deficits, making older adults more responsive than younger ones to the attention-enhancing effects of familiar music.

Although our findings on preference effects were robust and consistent across samples, the present study had limitations that could be addressed in future research. First, our sample was small, specially the one we used in Experiment 2. Second, we could have maximized even more preference and familiarity effects by personalizing stimulus sets, i.e., using a different stimulus set for each participant, following his/her own previous indication. Third, and most important, we used preference and familiarity as proxies for emotional engagement and attention-enhancement, respectively, but we did not test whether these were actually the mechanisms driving the variables under analysis. Future studies could address this by adding concurrent measures of emotional engagement (e.g., electrophysiological measures, like heart rate or skin conductance) and attention (e.g., a second behavioural task) under distinct levels of preference and familiarity.

Whatever the meaning of preference and familiarity effects in terms of underlying variables, our findings point to two important applications: first, not all background music is beneficial to memory performance; second, carefully-chosen music (specifically, preferred music) can be used as a memory enhancer in both younger adults — namely on the optimization of study/work conditions, and, most importantly, as an interesting tool to promote healthy aging. The fact that preferred music showed increased benefits in older participants in the lower range of cognitive status suggests that we might be dealing with a compensating mechanism (relying on emotional engagement to compensate for encoding weaknesses), which could perhaps be extended to older persons with more severe cognitive decline.

Conclusion

Our study contributed for a better understanding of the reasons why music may facilitate encoding. Our findings indicated that emotional engagement may be a key mechanism subtending the facilitating effects of music backgrounds on encoding across the life span, and that an attention-enhancement mechanism may emerge later in life. In terms of practical applications, our findings highlight the advantages of using preferred music as a background for verbal encoding tasks across the life span, and the possible advantages of familiar music in later stages of life.

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Appendix 1

Verbal stimuli used in Experiment 1 (Younger-adult participants)

Old words (n = 45)				New words (n = 45)			
Word	Length	Frequency	Status	Word	Length	Frequency	Status
1) Declarar	8	39	Verb	Candeio	7	39	Noun
2) Desligar	8	39	Verb	Escocês	7	40	Noun
3) Carência	8	40	Noun	Ilícito	7	40	adjective
4) Elementar	8	40	Adjective	Abjecção	8	41	Noun
5) Provedor	8	38	Noun	Ciclone	7	41	Noun
6) Religião	8	40	Noun	Grevista	8	41	Noun
7) Alumínio	8	41	Noun	Impalpável	10	41	adjective
8) Suculento	9	41	Adjective	Oitenta	7	41	Noun
9) Embebedar	9	43	Verb	Subverter	9	41	Verb
10) Totalizar	9	43	Verb	Congelador	10	42	Noun
11) Subjugar	8	44	Verb	Entulho	7	42	Noun
12) Enrascar	8	45	Verb	Descida	7	43	Noun

13) Península	9	45	Noun	Comadre	7	44	Noun
14) Reflexão	8	45	Noun	Contaminar	10	44	Verb
15) Mostarda	8	46	Noun	Delator	7	44	Noun
16) Restituir	9	46	Verb	Retirar	7	44	Verb
17) Silveira	8	46	Noun	Manifestar	10	45	Verb
18) Motivação	9	47	Noun	Relance	7	45	Noun
19) Paliativo	9	47	Adjective	Entrada	7	46	Noun
20) Conceder	8	48	Verb	Flutuar	7	46	Verb
21) Autocrata	9	49	Noun	Cegonha	7	47	Noun
22) Escavação	9	49	Noun	Cognome	7	48	Noun
23) Emagrecer	9	50	Verb	Psiquiatra	10	48	Noun
24) Prontidão	9	50	Noun	Replica	7	48	Noun
25) Alcovitar	9	51	Verb	Urgente	7	48	adjective
26) Capacete	9	51	Noun	Producente	10	50	adjective
27) Documento	9	51	Noun	Condimento	10	52	Noun

28) Revestir	8	51	Verb	Participar	10	52	Verb
29) Infringir	9	52	Verb	Desempatar	10	53	Verb
30) Prodígio	8	52	Noun	Bilhete	7	54	Noun
31) Vasculhar	9	53	Verb	Mercado	7	54	Noun
32) Arrecadar	9	54	Verb	Petrificar	10	56	Verb
33) Retirado	8	54	Noun	Viscoso	7	56	Noun
34) Capelinha	9	55	Noun	Descrédito	10	57	Noun
35) Depilação	9	55	Noun	Feiticeira	10	58	Noun
36) Explícito	9	55	Adjective	Particular	10	58	adjective
37) Acetinar	8	56	Verb	Rotunda	7	58	Noun
38) Denuncia	8	56	Noun	Pousada	7	59	Noun
39) Repudiar	8	56	Verb	Afastado	8	60	adjective
40) Imunidade	9	57	Noun	Colossal	8	61	Noun
41) Palpitar	8	57	Verb	Parteira	8	61	Noun
42) Cavalaria	9	58	Noun	Atenuante	9	62	Noun

43) Segmentar	9	58	Verb	Produzir	8	62	Verb
44) Benjamim	8	59	Noun	Reprovar	8	62	Verb
45) Combinar	8	60	Verb	Tarifar	7	62	Verb
M $\pm$ *SD*	8.5 $\pm$ 0.5	49.2 $\pm$ 6.2			8.1 $\pm$ 1.3	49.7 $\pm$ 7.7	
Verb, Noun, Adjective			19,22,4				11,18,6

Appendix 2

Pool of music stimuli used in the pre-test (selected stimuli marked on the last column). Familiarity ratings and average preference contrasts are listed, as found in a pre-test with 20 younger adults.

ID	Performer - Song	Genre	Familiarity ratings	Inclusion in final test
1	**John 5 and The Creatures - HERE'S TO THE CRAZY ONES**	**Metal**	**0**	**selected**
2	Deftones - U, U, D, D, L, R, L, R, A, B, Select, Start	Metal	1	
3	Metallica – Orion	Metal	9	
4	J Dilla – Life	Hip Hop	1	
5	Jay-Z - Dead Presidents	Hip Hop	3	
6	Mobb Deep - Shook Ones (instrumental)	Hip Hop	6	
7	**Robert Miles – Children**	**Electronic**	**12**	**selected**
8	BICEP | GLUE	Electronic	0	
9	Popof - Do You Want Me	Electronic	5	
10	**Thelonious Monk - Blue Monk**	**Jazz**	**1**	**selected**
11	Dave Brubeck - Take Five	Jazz	9	
12	Open Source Trio – Altitude	Jazz	2	

Song pair	Average preference contrast (in points, 1-10)
1 vs. 7	2.15
1 vs. 10	2.55
7 vs. 10	2

Appendix 3

Verbal stimuli used in Experiment 2 (elderly participants)

Old words (n = 10)				New words (n = 10)			
Word	Length	Frequency	Status	Word	Length	Frequency	Status
Declarar	8	39	Verb	Candeio	7	39	Noun
Desligar	8	39	Verb	Escocês	7	40	Noun
Carência	8	40	Noun	Ilícito	7	40	Noun
Elementar	8	40	Noun	Abjecção	8	41	Noun
Provedor	8	38	Noun	Ciclone	7	41	Noun
Religião	8	40	Noun	Grevista	8	41	Noun
Alumínio	8	41	Noun	Impalpável	10	41	Adjective
Suculento	9	41	Adjective	Oitenta	7	41	Noun
Embebedar	9	43	Verb	Subverter	9	41	Verb
Totalizar	9	43	Verb	Congelador	10	42	Noun
M ± *SD*	8.3 ± 0.5	40.4 ± 1,6			8.0 ± 1.2	40.7 ± 0.8	
Verb, Noun, Adjective			4,5,1				1,8,1

The effects of preference and familiarity of background music on word encoding

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